

cally insulating tubular enclosure. The platinum wire has limited thermal contact with the support and, in turn, with the enclosure. Therefore, heat generated in the wire is not easily dissipated to the surroundings of the RTD. Therefore, self-heating errors can become quite large unless the RTD current is kept very low. In addition, the RTD enclosure may have limited ability to dissipate heat to its surroundings. For example, if the RTD is immersed in stagnant gas, heat dissipation will be limited. This limited ability to dissipate heat to the surroundings of the RTD further restricts the RTD current to low values.

Thin film RTDs comprise a thin film of platinum deposited in a serpentine pattern on an electrically insulating substrate. The platinum resistor is covered with a dielectric, e.g., a glass or an alumina layer, to protect it from physical damage. Because the resistor exists as a thin film deposited directly on the substrate, the thermal resistance between the resistor and the enclosure is eliminated and the temperature of the resistor and its enclosure will be essentially identical. Thus, one source of self-heating errors is removed. The problem of dissipation of heat from the RTD enclosure to its surroundings is still present, however, and may result in self-heating errors.

SUMMARY OF THE INVENTION

The present invention is a differential scanning calorimeter that has constant calorimetric sensitivity. The present invention uses two RTD sensors whose current is varied as a function of temperature, such that the amplitude of the signal produced by the RTD is constant, for a given heat flow, over the entire range of the DSC's operating temperatures. The DSC sensor of the present invention comprises a pair of platinum thin-film resistors supported by an electrically insulating substrate. One of the thin-film platinum resistors measures the temperature of the sample region of the support, and the other thin-film resistor measures the temperature of the reference region of the support. The amplitude of the sensing current for each RTD is selected based upon the temperature of that RTD.

The voltage across the sample thin-film resistor is a measure of the temperature of the sample, and the difference between the voltages across the sample and reference thin-film resistors is a measure of the differential flow of heat to the sample. Because the thin film platinum resistors are an integral part of the support, and because the temperature of the support is the parameter that is actually being measured, there is no measuring error due to heat generation in the platinum resistors, and the sensing current can be freely chosen. Thus the current applied to the sensor can be varied, according to the temperature of the sensor, to offset the changes in calorimetric sensitivity due to changes in the resistance of the sensing element and changes in thermal diffusivity of the support means. A differential scanning calorimeter made in accordance with this invention will therefore have a calorimetric sensitivity which is constant over the range of operating temperatures.

As shown in FIG. 1 and FIG. 1a, the thin-film RTD of the present invention is fabricated by depositing a serpentine thin film of platinum on an electrically insulating substrate. The thin platinum film is covered with a protective layer of a dielectric material, such as alumina or glass. Because the resistance element is an integral part of the substrate on which it has been deposited, the thermal resistance between the sensing element and the sample or reference positions on the substrate whose temperature is being measured is eliminated.

However, a thermal resistance will still exist between the object—the sample or the reference—being measured and the sensor substrate. In the present invention, there is no self-heating error in measuring the temperature of the substrate, regardless of the current applied to the sensor. Thus, within the normal operating temperature range of the sensor, the substrate temperature is measured correctly.

The platinum thin film resistors are applied to ceramic substrates, because ceramic substrates are electrical insulators, can operate at a wide range of temperatures, and are readily adapted to thin film processing. The thermal diffusivity of ceramics varies over a wide range, from the high diffusivity of beryllia ceramic to the low thermal diffusivity of zirconia. By choosing the ceramic substrate, sensors can be made with a very rapid dynamic response (and a lower calorimetric sensitivity) or with a much slower dynamic response (and a greater calorimetric sensitivity) i.e., a rapid dynamic response can be obtained by choosing a substrate with a high thermal diffusivity, or greater thermal diffusivity can be obtained by choosing a substrate with a low calorimetric sensitivity.

It is an object of this invention to provide a differential scanning calorimeter using thin film platinum RTD sensors, which have constant calorimetric sensitivity.

It is a further object of the present invention to provide thin film RTD DSC sensors in which the excitation current is varied in accordance with the temperature of the object (sample or reference) being measured, such that the calorimetric sensitivity of the sensor is constant.

It is a further object of the present invention to provide a differential scanning calorimeter which has a dynamic response which may be high, low or intermediate, depending upon the sensor substrate chosen.

BRIEF DESCRIPTION OF THE FIGURES

FIG. 1 is a schematic diagram showing the construction of a disk-type differential scanning calorimeter sensor using RTD temperature sensors for use in a constant calorimetric sensitivity differential scanning calorimeter system.

FIG. 1a is a cross-section of a portion of the substrate used in the disk-type differential scanning calorimeter of FIG. 1.

FIG. 2 is a functional block diagram of a constant calorimetric sensitivity differential scanning calorimeter.

FIG. 3 is a schematic diagram showing the construction of a disk-type differential scanning calorimetry that uses separate RTD sensors mounted to the disk.

FIG. 4 is a schematic diagram showing the construction of a twin-lug differential scanning calorimeter sensor using RTD temperature sensors for use in a constant calorimetric sensitivity differential scanning calorimeter system.

DETAILED DESCRIPTION OF THE INVENTION

FIG. 1 is a schematic diagram of a first embodiment of a disk-type RTD differential scanning calorimeter sensor for use in a constant calorimetric sensitivity DSC system of the present invention. FIG. 1 is a bottom view of disk substrate 11. The sample and reference materials are placed on the top surface of substrate. In this first preferred embodiment of the present invention, substrate 11 is a polycrystalline ceramic disk, e.g., alumina, aluminum nitride, beryllia, zirconia or other ceramic disk. Other materials which are electrical insulators, have the desired thermal diffusivity, and are amenable to thin film processing such as monocrystalline ceramics, e.g., sapphire or amorphous materials, i.e., glasses